Airborne Science Program

Observing Platforms for Earth Systems Science Investigations

http://airbornescience.nasa.gov

The Airborne Science Program: Accessing NASA Aircraft Services

- Program Overview

- Available Platforms

- Engineering and Payload Integration Details:
  Aircraft Mechanical, Electrical, and Telemetry Interfaces

- Administrative details:
  Flight Request Process
  Airworthiness and Flight Readiness Reviews

Airborne Science Program Objectives

<u>Satellite Calibration and Validation</u>

Provide platforms to enable essential calibration measurements for the Earth observing satellites, and the validation of data retrieval algorithms.

<u>Support New Sensor Development</u>

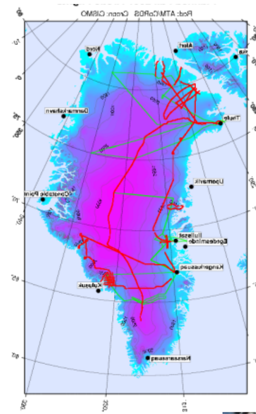
Provide sub-orbital flight opportunities to test and refine new instrument technologies and retrieval algorithms, and reduce risk for future orbital missions.

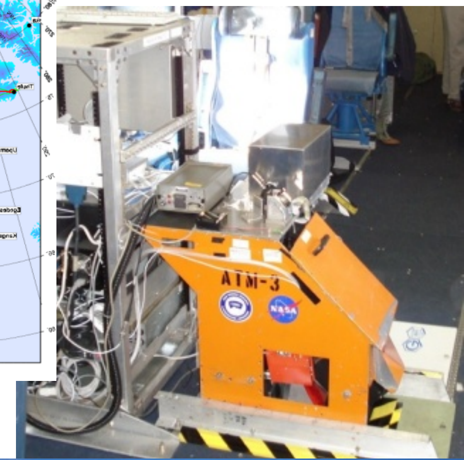
<u>Process Studies</u>

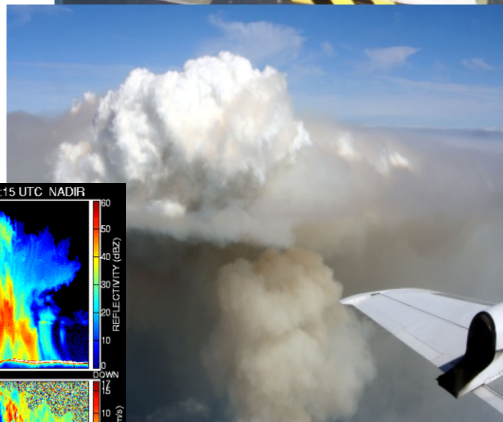
Obtain high-resolution temporal and spatial measurements of complex local processes, which can be coupled to global satellite observations for a better understanding of the complete Earth system.

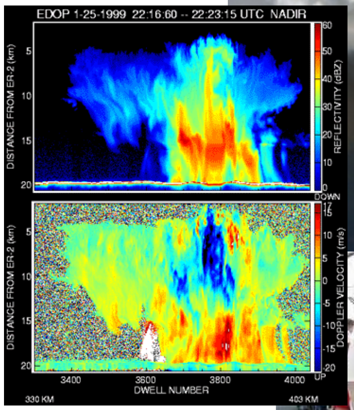
<u>Develop the Next-Generation of Scientists and Engineers</u>

Foster the development of our future workforce with the hands-on involvement of graduate students, and young scientists/engineers in all aspects of ongoing Earth science investigations.









Specific Services

- Facilitates access to airborne assets capable of supporting NASA's scientific measurements
  - ASP core platforms, other NASA, Federal, and commercial platforms
  - Insures compliance with NASA airworthiness directives (NPD 7900.4b,) SMD, NASA and OMB reporting requirements, and authority and liability

- Provides capabilities to enhance/enable scientific measurements
  - Mission/Project Management and Logistics
  - Science support systems
  - Airborne data networks
  - Payload engineering support
  - Approvals for laser and radiation, dropsonde release, pressure vessel safety, HAZMAT, EMI, foreign clearances, etc

Currently Available Platforms

https://airbornescience.nasa.gov/aircraft

Role: Remote sensing, Upper Tropospheric and Stratospheric In situ sampling

Altitude:	70,000 ft
Payload:	2,900 lbs
Range:	5,000 + Nmi


ER-2

Role: Long duration high-altitude remote sensing; upper Tropospheric and Stratospheric in situ sampling

Altitude:	65,000 ft
Payload:	1,500 lbs
Range:	11,000 Nmi


Global Hawk

Role: Remote sensing, Upper Tropospheric and Stratospheric In situ sampling, vertical profiling

Altitude:	60,000 ft
Payload:	8,800 lbs
Range:	2,172 Nmi


WB-57F

Role: UAVSAR and mid-altitude remote sensing

Altitude:	45,000 ft
Payload:	2,610 lbs
Range:	3,400 Nmi


G-III/C-20A

Role: Remote sensing, Upper Tropospheric and Stratospheric In situ sampling

Altitude:	42,000 ft
Payload:	3,000 lbs
Range:	1,900 Nmi

Hu-25 Falcon

Role: Remote sensing, Upper Tropospheric and Stratospheric In situ sampling

Altitude:	42,000 ft
Payload:	3,200 lbs
Range:	1,200 Nmi

Learjet 25

Role: Tropospheric In situ sampling, vertical profiles, Synthetic Aperture Radar, remote sensing

Altitude:	41,000 ft
Payload:	30,000 lbs
Range:	5,400 Nmi

DC-8

Role: Remote sensing, Laser profiling, Tropospheric In situ sampling

Altitude:	32,000 ft.
Payload:	14,700 lbs
Range:	1,883 Nmi

P-3B

Role: Mid-altitude remote sensing and In situ sampling

Altitude:	33,000 ft.
Payload:	36,50000 lbs
Range:	1,050 Nmi

Role: Mid-altitude remote sensing and In situ sampling

Altitude:	28-35,000 ft. (RVSM)
Payload:	4,100 lbs
Range:	3,800 Nmi

Role: Medium lift, medium altitude remote sensing

Altitude:	20,000 ft
Payload:	7,000 lbs
Range:	1,000 Nmi

Role: Low-altitude remote sensing and In situ sampling

Altitude:	25,000 ft
Payload:	5,000 lbs
Range:	500 Nmi

Role: Long duration mid-altitude remote sensing and in situ sampling; real-time disaster response imaging

Altitude:	41,000 ft
Payload:	3,000 lbs
Range:	3,500 Nmi

Ikhana UAS

Role: Low altitude remote sensing and in situ sampling

Altitude:	12,000 ft
Payload:	100 lbs
Range:	550 Nmi


SIERRA UAS

Role: Low altitude remote sensing and in situ sampling

Altitude:	15,000 ft
Payload:	100 lbs
Range:	720 Nmi


Viking UAS

Role: Low altitude in situ sampling

Altitude:	1,000 ft
Payload:	8 oz (227 gms)
Range:	10 km (line-of-sight)

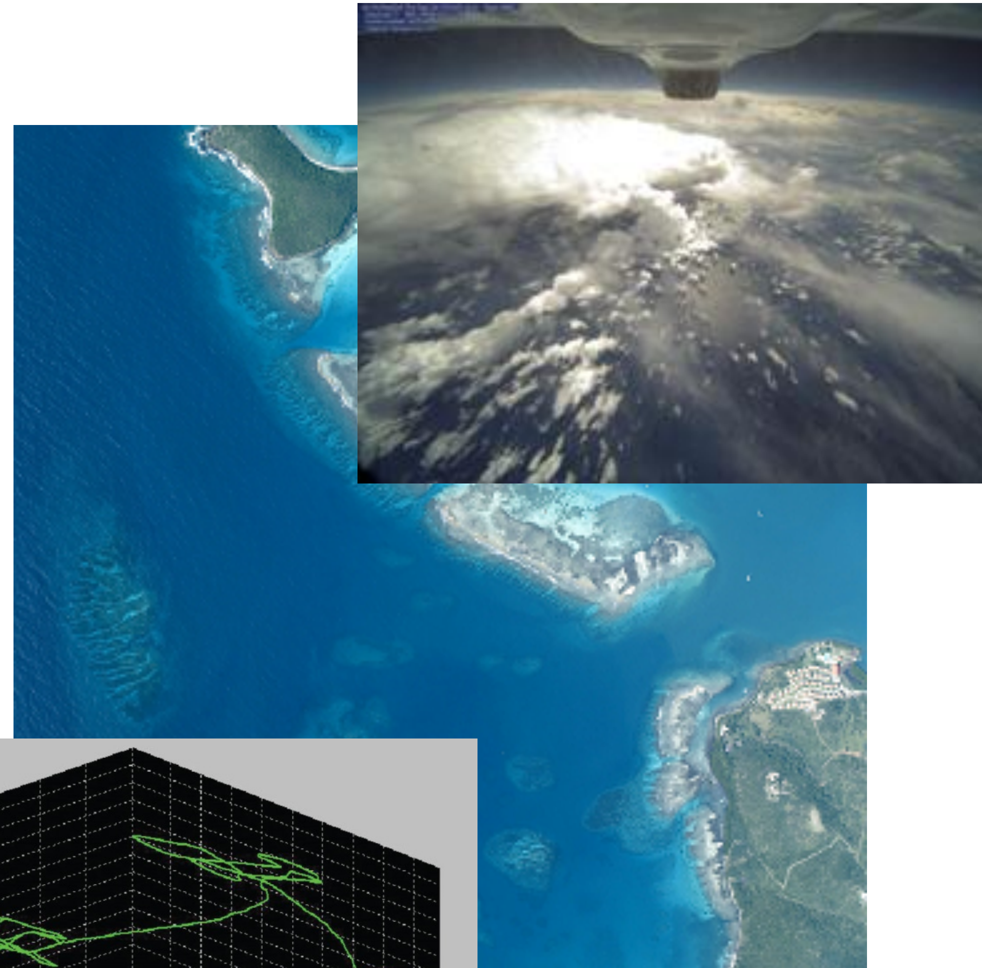
Dragon Eye UAS


Mission-specific FAA COAs Required for Most UAS flights

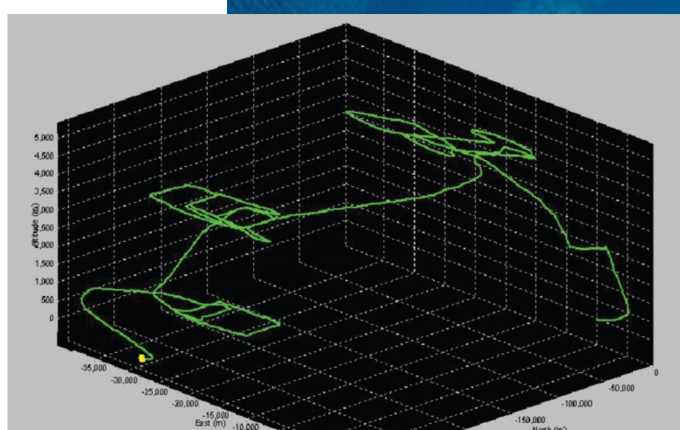
Facility Systems

Available for loan on approved Flight Requests

Electro-Optic and Video Tracking Cameras



Precision Attitude Reference Systems (Applanix 510 & 610s)

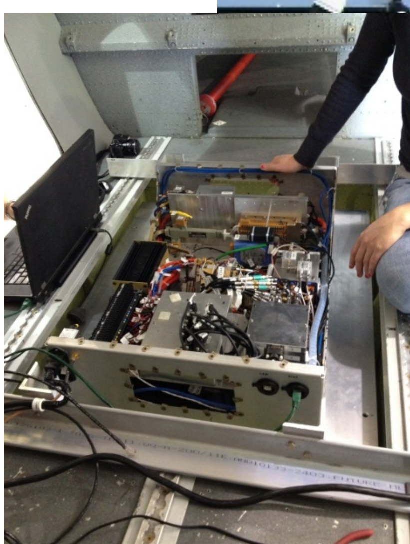


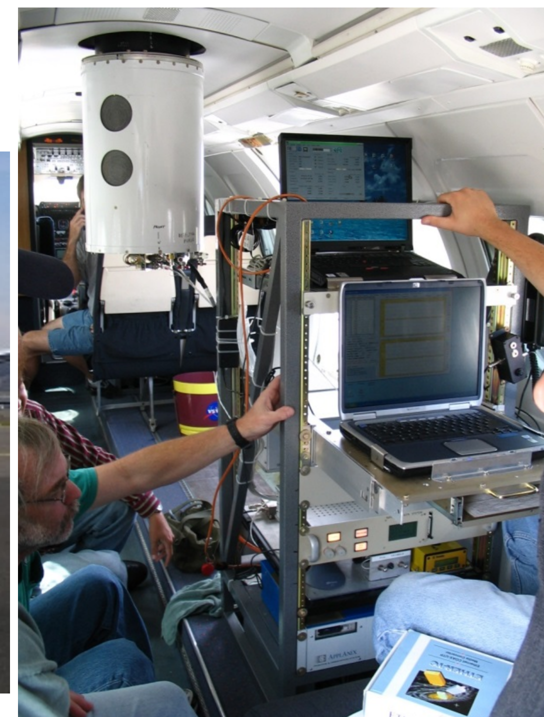
Some costs may apply

Engineering & Platform Integration

Mechanical mounting structures must meet NASA airworthiness standards, as specified for each aircraft type. Design and fabrication of fixtures is a negotiated responsibility between the aircraft provider and the instrument team.

Structural stress analysis is required in most cases.





Electrical and Communications Connections

Standard aircraft power is 28V DC, with options for 115V 400Hz 3-phase AC

Two-way data communications and real-time state data are typically provided via the onboard NASDAT Ethernet network to the instruments on the larger platforms.

Instrument power and safety interlocks are controlled by hardwire

Time-stamping can be done via the NASDAT NTP server (preferred) or IRIG-B

The NASDAT Airborne Server

(NASA Airborne Science Data and Telemetry system)

- Ingests, records, and re-broadcasts aircraft avionics and state data (AIRINC-429, -1553)
- Server for the onboard Ethernet network & Network Time Protocol (NTP)
- Sat-Com interface for science data packets, instrument status and commands, for users on the ground
- Uses standard IGWADTS* data transmission protocols (IWG-1 packets, etc.)
- Includes a 4-channel Iridium link for global baseline payload communications
- 32 GB of data storage, stabilized internal time references, and back-up GPS

Standard installation on the core ASP platform; optional on some smaller aircraft.

* Inter-Governmental Working Group for Airborne Data & Telemetry Systems

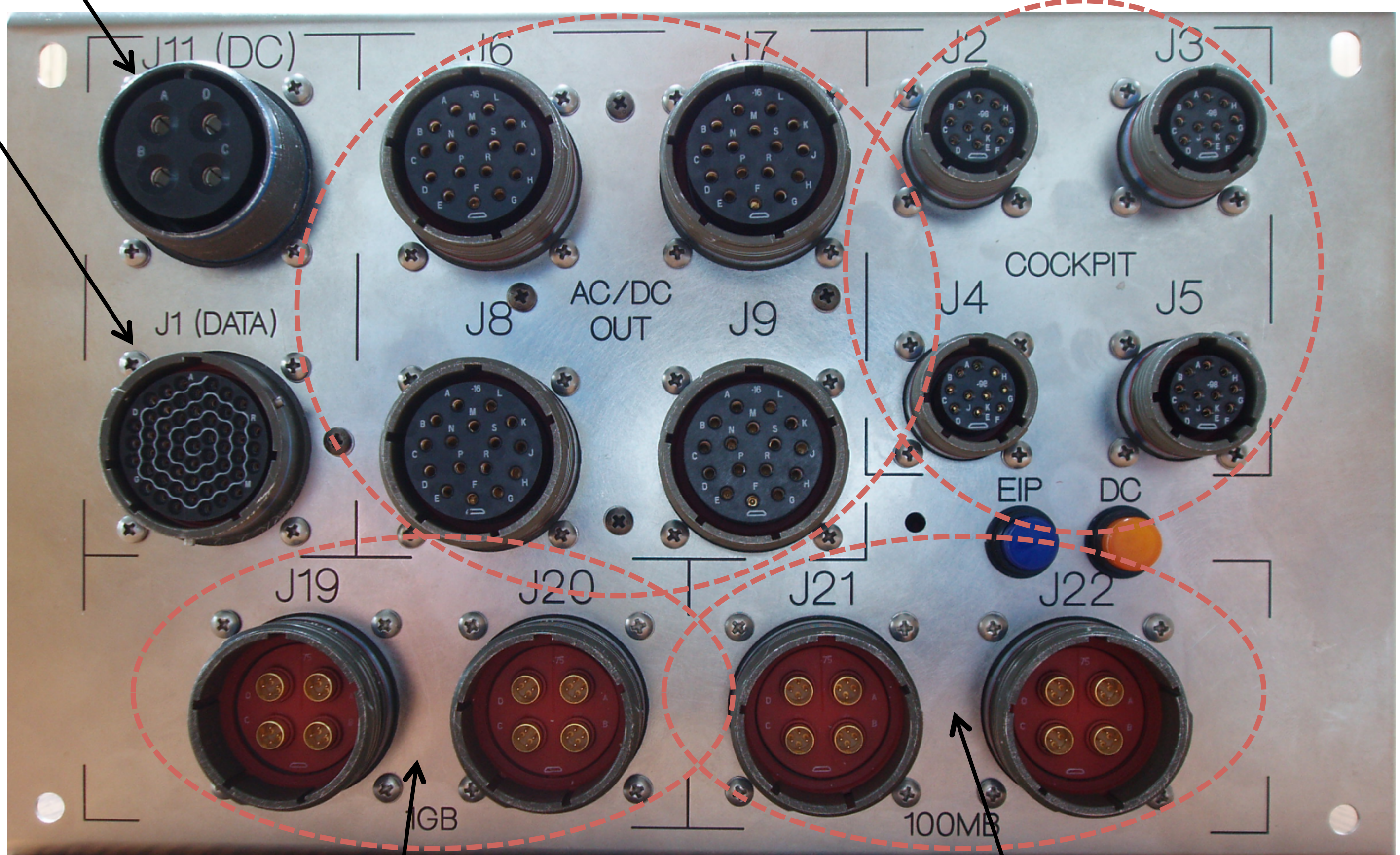
Experiment Interface Panel
(ER-2, WB-57, Global Hawk)

“DC” (35A x2)

“AC/DC” (28V, 400Hz, switches)

“COCKPIT” (switches)

“DATA” (legacy)

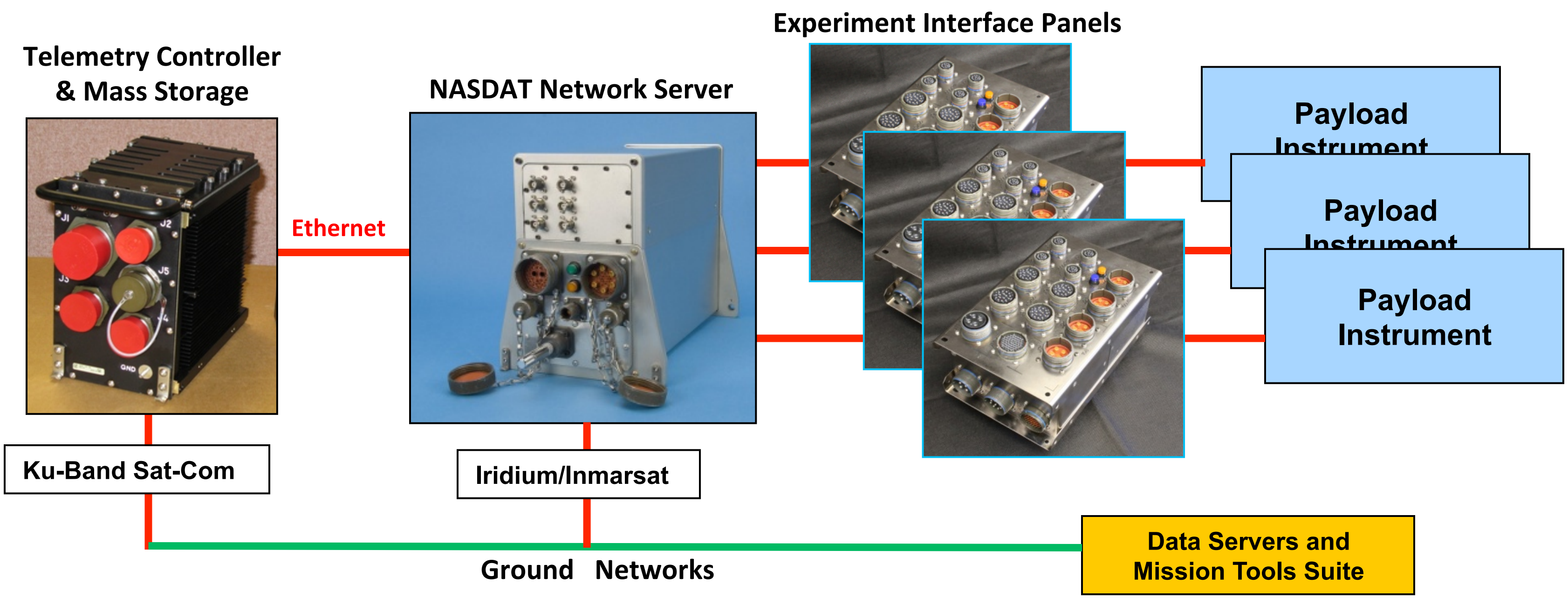


“1GB” (4x 1000BASE-T Ethernet)

“100MB” (8x 10/100BASE-T Ethernet)

The DC-8, P-3, and C-130 have similar provisions, using somewhat different connectors.

Payload Sensor Network Communications



(DC-8, P-3B, C-130 have Ethernet networks installed, but do not use the Experiment Interface Panels.)

Sensor Network Services

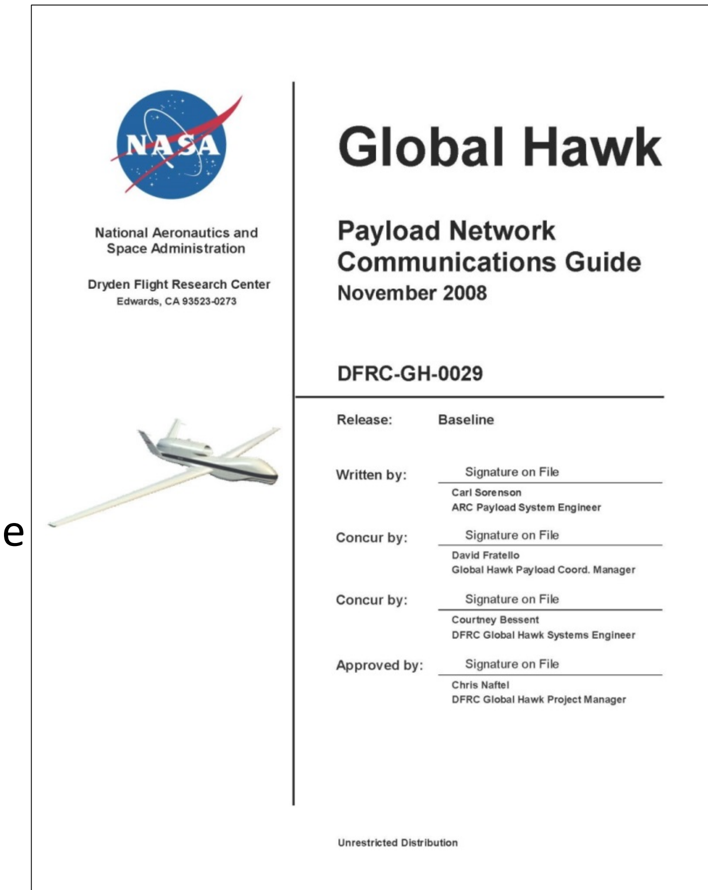
Protocols are defined in the Global Hawk Payload Communications Guide.

The NASDAT server broadcasts a standard 1 Hz “IWG-1” ASCII CSV packet with platform state data

Instruments may broadcast a similar packet with engineering health status (required on GH)

Optional “User-Defined” science data packets may be sent, with the data volume a function of available sat-com bandwidth

Users may send commands up the link to their instruments (some restrictions may apply)



National Aeronautics and Space Administration

Dryden Flight Research Center
Edwards, CA 93523-0273

Global Hawk

Payload Network Communications Guide
November 2008

DFRC-GH-0029

Release: Baseline

Written by: Signature on File
Carl Sorenson
ARC Payload System Engineer

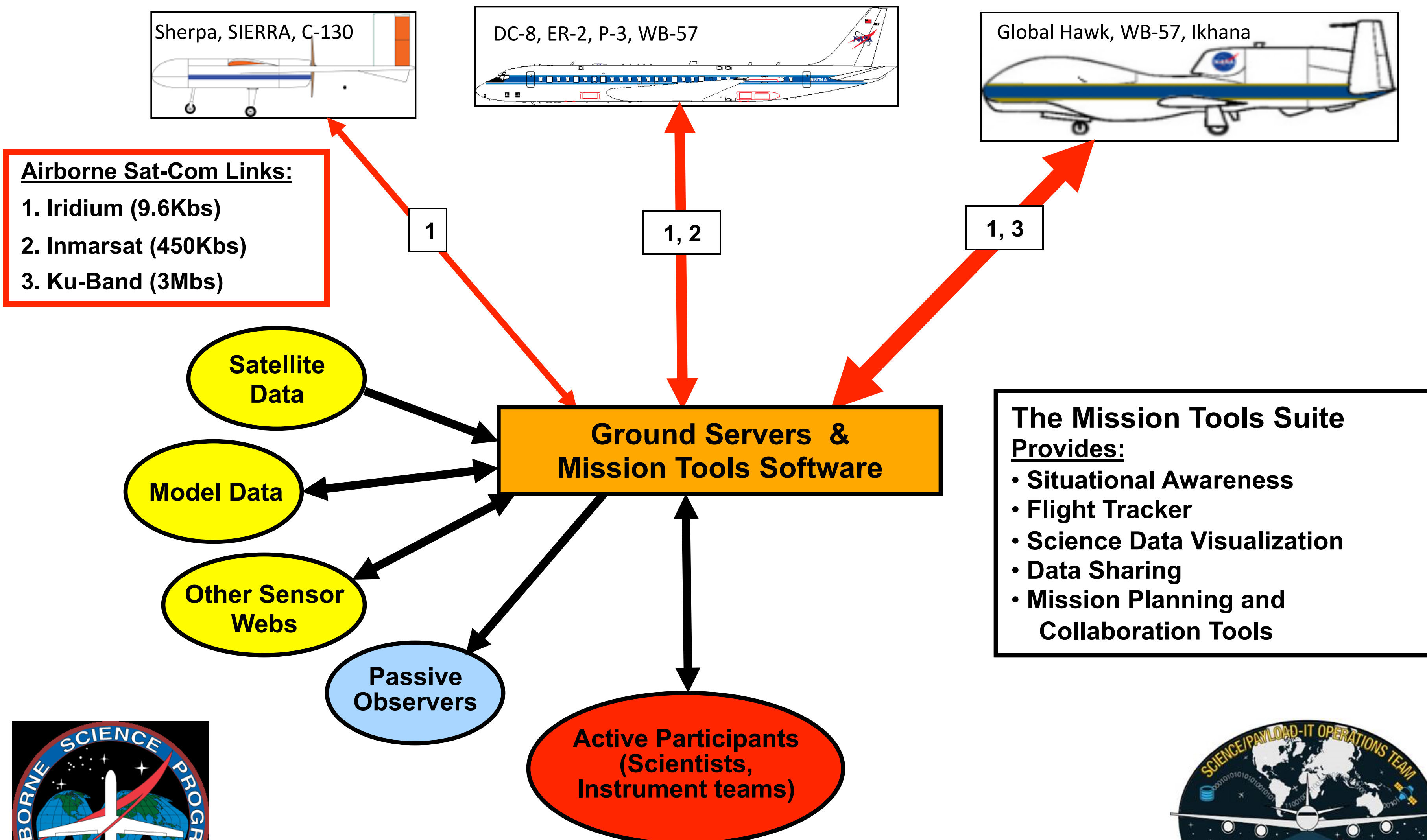
Concur by: Signature on File
David Fratello
Global Hawk Payload Coord. Manager

Concur by: Signature on File
Courtney Bessent
DFRC Global Hawk Systems Engineer

Approved by: Signature on File
Chris Naftel
DFRC Global Hawk Project Manager

Unrestricted Distribution

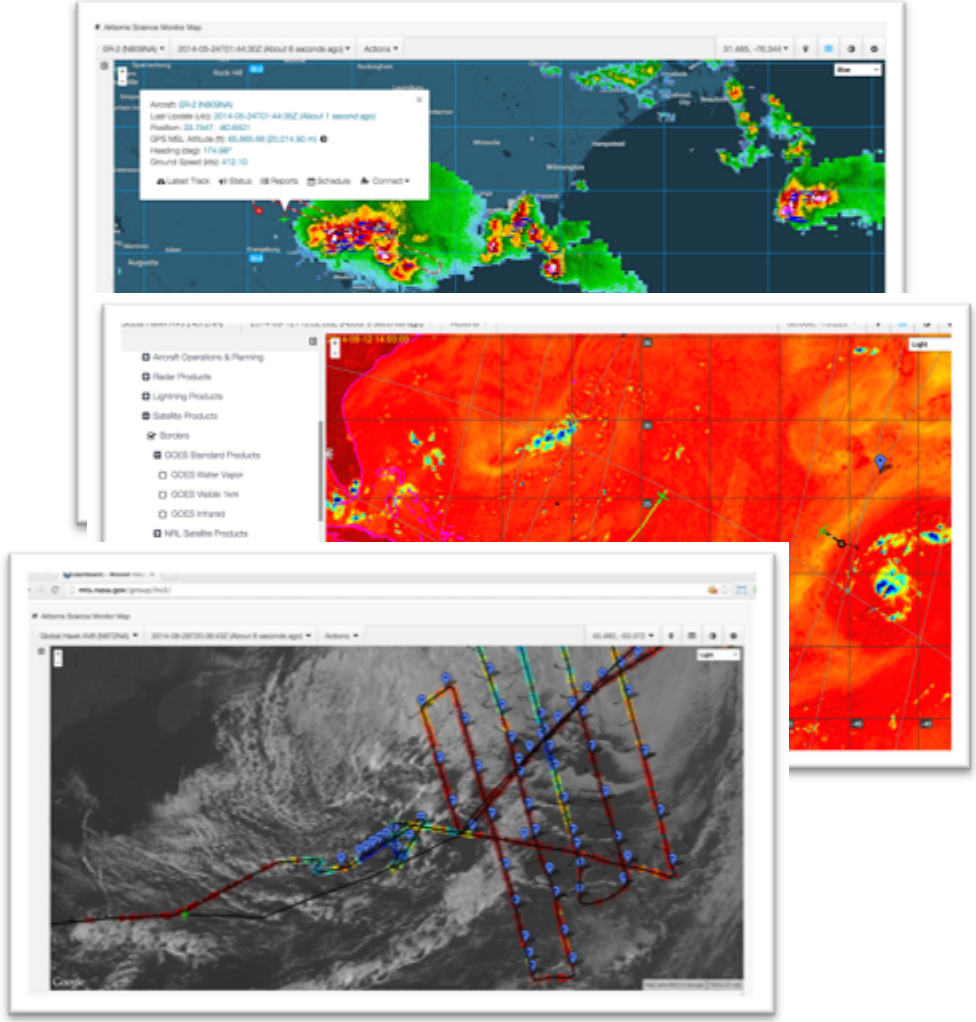
The Real-Time Airborne Sensor Network Architecture



Mission Tools Suite (MTS)
For asset tracking and real-time science

MTS Supports:

- Tactical decision-making and distributed team situational awareness during a flight
- Real time position and instrument status visualization for single and multi-asset campaigns
- Access to low latency satellite, radar, and other meteorological and mission products
- Communication and collaboration tools including a full CMS and turn-key chat solutions
- Robust support for Education and Public Outreach participation



Project Lead: Aaron R. Duley, Ph.D.
Ames Research Center, Moffett Field, CA
For more information visit: http://mts.nasa.gov

Administrative Details:

All aircraft activities start with a NASA Flight Request, indicating funding source and project specifics. This is mandatory for all NASA-related flight activities.

Instrument team contacts their preferred aircraft provider, who will provide cost estimates for system integration and flight costs

Engineering tasks are mutually negotiated with the aircraft provider

Flight Request: AirSWOT Engineering Test Flights
Submitted: 15 Oct, 2014

Approved - 15B004

General Info

Project Title: Request Type: NASA Funded: ROSES Call: Flight Hours Requested (if known):	AirSWOT Engineering Test Flights Normal Yes No 15	**Status: Log Number: Fiscal Year: Contract Grant # (if applicable):**	Approved 15B004 2014

Rationale for use of NASA Facilities:

Flight Hours	14B009	15B004	Total Hours:
For Approval:			
Approved:	53		53
Previously Approved:	53	28.1	
Flown:	24.9		24.9
Cost Estimate Due Date: Flight Hours: MPC: Integration: Other:	$75,642 $18,390 $5,750		
Current Total:	$99,782	$99,782	
Previously Approved: Total Cost:	$99,782	$99,782	
Comments:	Estimate for engineering & ocean/hydrology validation flight series. 8.4 hours carried over from 2013.		

Sample Flight Request
https://airbornescience.nasa.gov/sofrs

Piggyback Request: No

FR ID: 20141015-064738

Originally was 14B009; Most recent version is 15B004 Rollover

Log #	Relation	Status	Aircraft	Title
14B009	Original	Partial	B-200 - DFRC	AirSWOT Engineering Test Flights
15B004	Rolled over 14B009	Approved	B-200 - DFRC	AirSWOT Engineering Test Flights

PI & Funding Principal Investigator

Gregory Sadowy - Jet Propulsion Laboratory

Funding Source

Parag Vaze - NASA - SMD - ESD SWOT Project Manager

NASA HQ Science Concurrence

Eric Lindstrom - NASA - SMD - ESD Oceanography

Science Objectives and Mission Concept-of-Operation Science Objectives:

Demonstrate performance of AirSWOT instrument. Diagnose issues, if required. Record engineering baseline for performance

Mission Concept-of-Operation:

Sortie Type 1: Local flights over Rosamond Lake Sortie Type 2: Transit to Monterrey from DFRC, refuel, fly long like over ocean return to

NASA Procedural Requirements
NPR 7900.4B
Effective Date: June 14, 2007
Expiration Date: June 14, 2012
COMPLIANCE IS MANDATORY
Aircraft Operations Management
Responsible Office: Aircraft Management Division
NASA Interim Directive: Unmanned Aircraft System (UAS) Policy Update, NM 7900-83
NASA Interim Directive: NASA Procedural Requirement (NPR) 7900.3B, NASA Aircraft Operations Management, NM 7900-65

http://nodis3.gsfc.nasa.gov/npg_img/N_PR_7900_004B_/N_PR_7900_003B_.pdf

NASA policy requires formal airworthiness and flight readiness review for *any* aircraft operations, public or private, that involve NASA-funded instruments, or personnel (including contractors or grantees.)

NASA review boards are convened at Wallops, Langley, Glenn, Armstrong, and Ames.

Airworthiness & Flight Safety Review Board (AFSRB) and Flight Readiness Review (FRR) Outlines

1. Project summary and timeline

2. Platform

3. Base of operations

4 . Instrument – description and application
Instrument engineering and installation
Instrument operation
Approvals for Laser and Radiation, dropsonde release, pressure vessel safety, HAZMAT safety, EMI, etc.

5. Study site – map / Flight plan - map
(Flight lines, Flight altitude(s,) Sun angle requirements – time of day

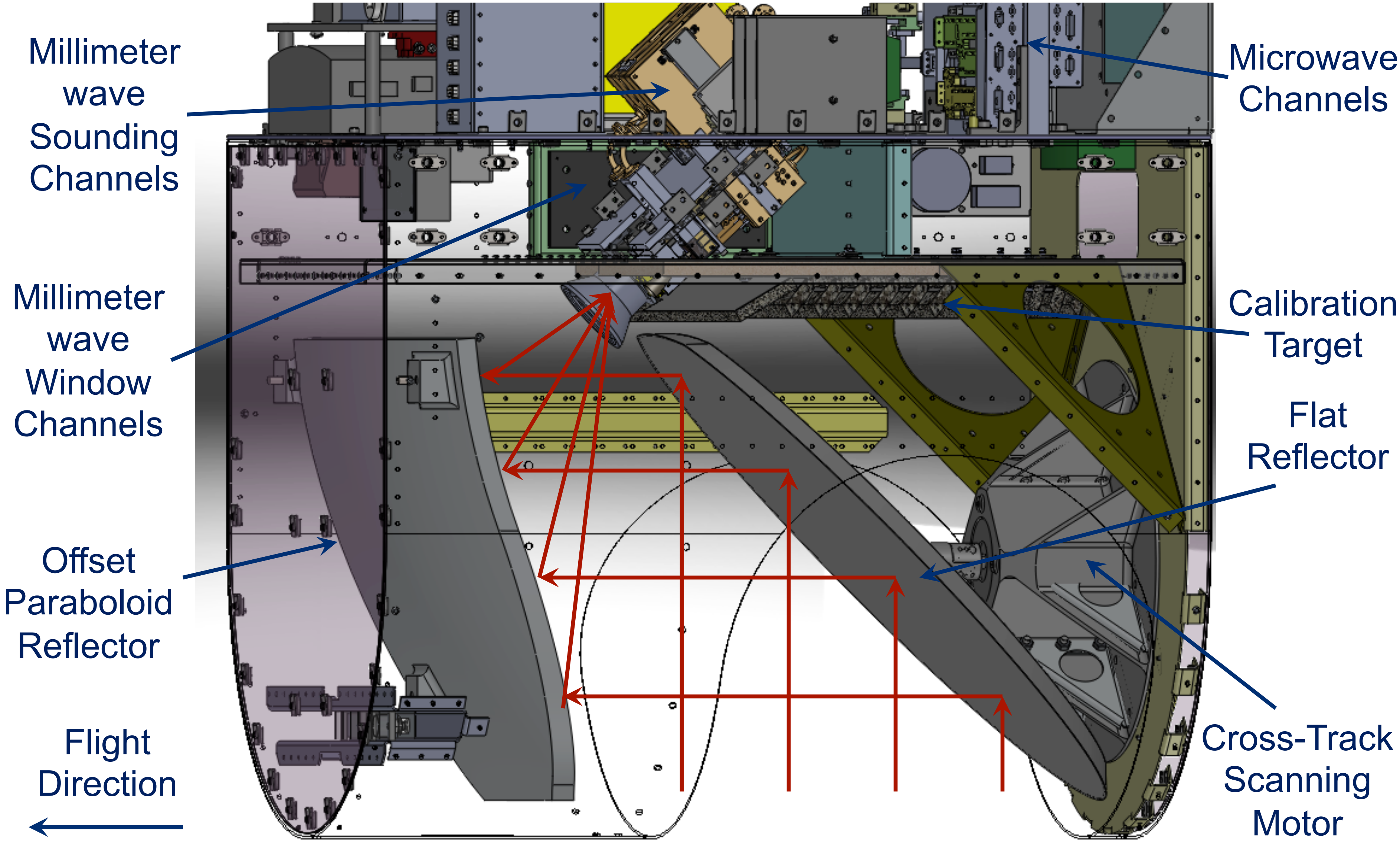
7. Test plan

8. Safety plan – Risk management/Risk matrix,
Instrument operator – medical clearance?

9. Mishap plan

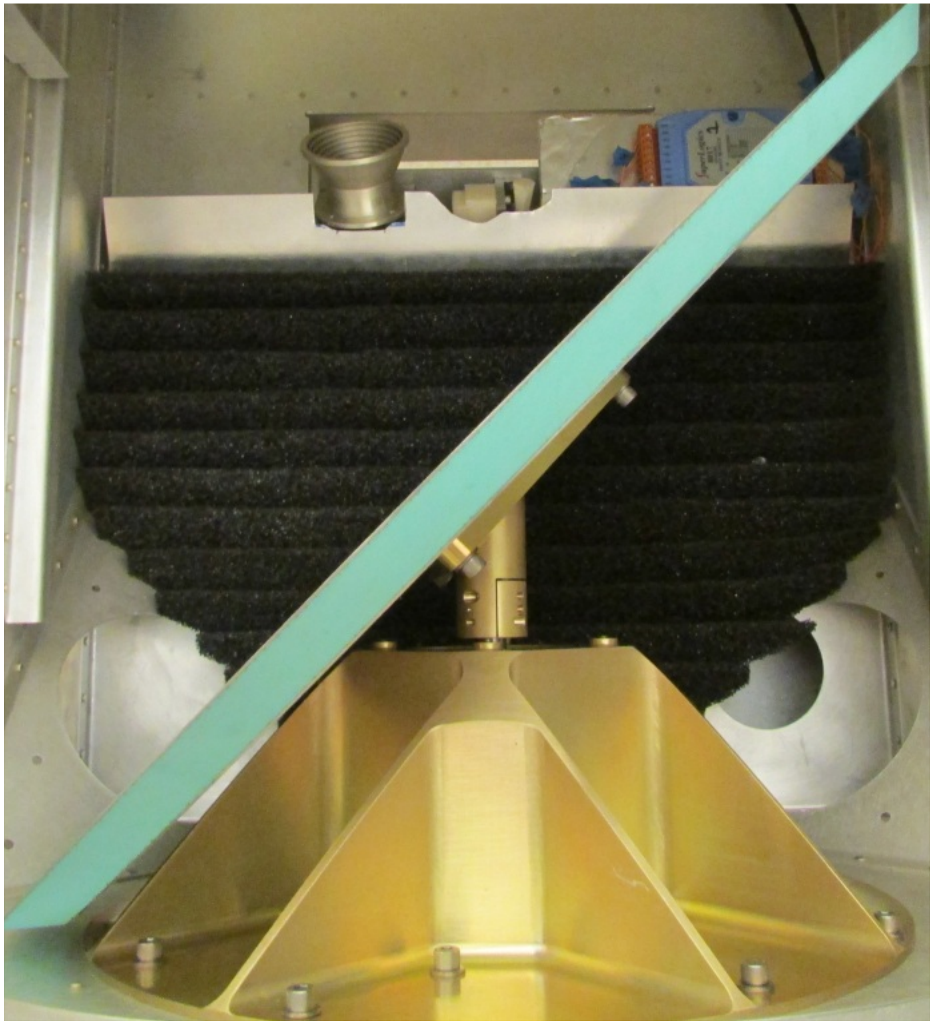
Example Content From an FRR/ARB (partial only)

HAMMR Instrument Design

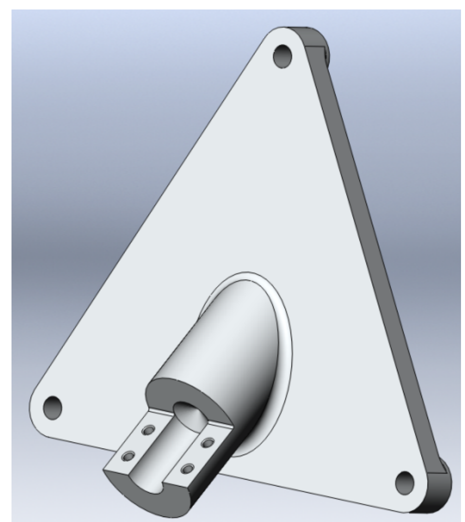


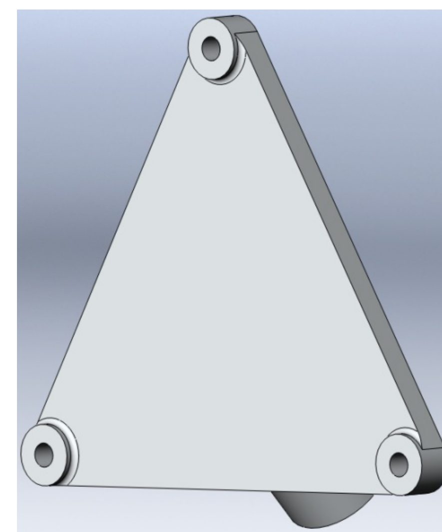
(Courtesy of Colorado State University/JPL)

Flat Reflector Interface



- Three attachment points
  - Each with ¼-28 steel fastener and locking helicoil insert.
  - Manufactured by NCAR EOL DFS from 6061-T6 aluminum.

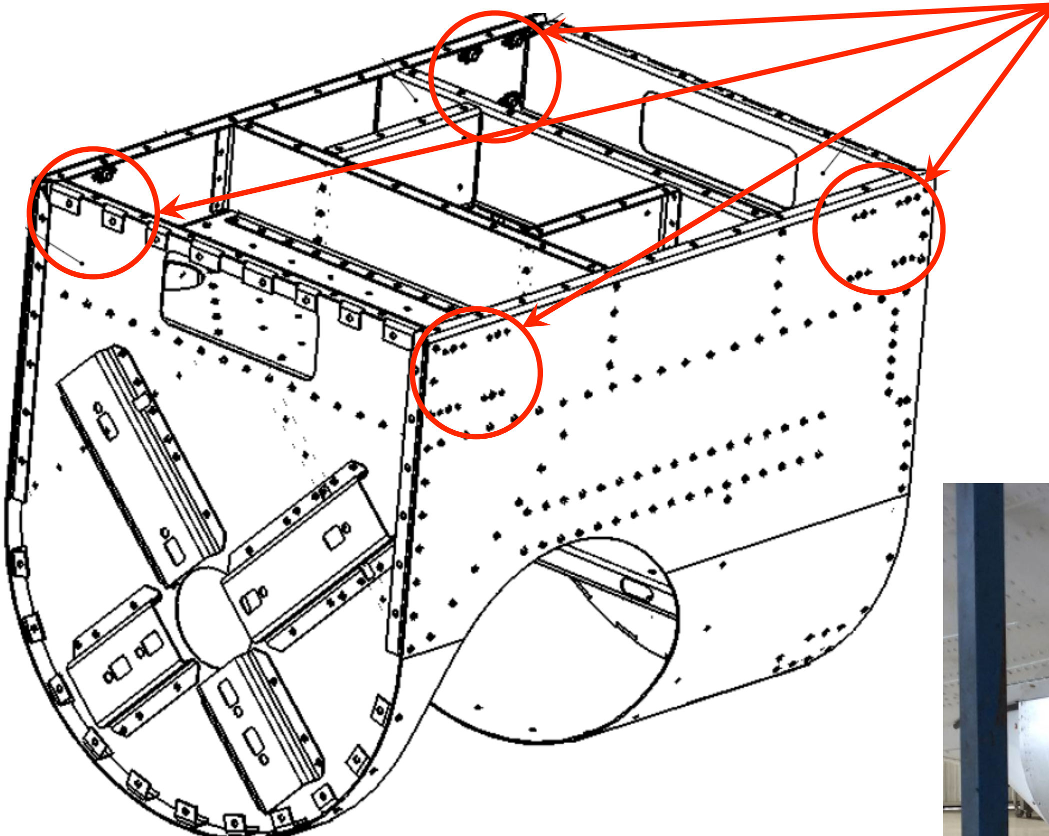




(Courtesy of Colorado State University/JPL)

Aircraft Interface Design Details

(HAMMR Example)

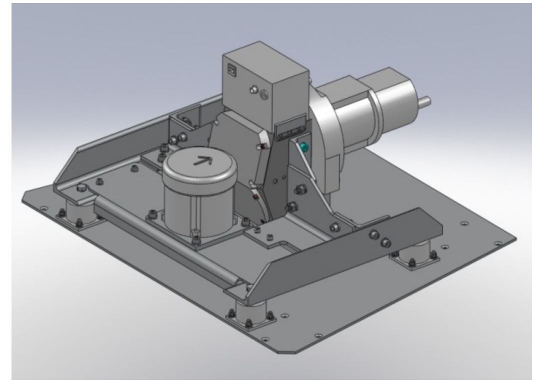


- 16 attachment points
  - Each with ¼-28 MS21059 nut plates.
  - Chassis designed by ATK Spacecraft Systems and Services and constructed from 6061-T4 aluminum.

(Courtesy of Colorado State University/JPL)

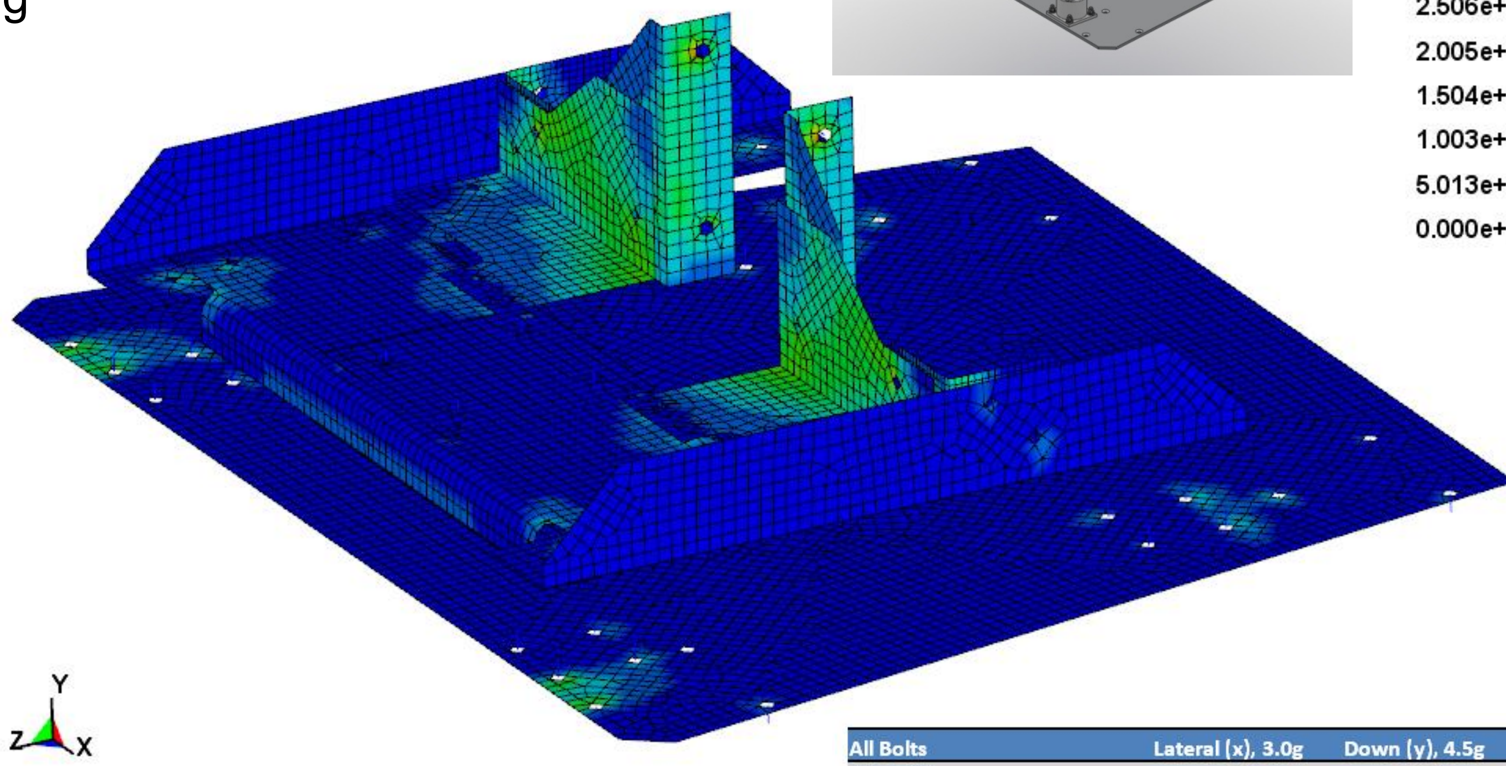
Structural Substantiation
(Headwall example)

Contours of Effective Stress (v-m)
max ipt. value
min=0, at elem# 57
max=5012.94, at elem# 11648



Fringe Levels
5.013e+03
4.512e+03
4.010e+03
3.509e+03
3.008e+03
2.506e+03
2.005e+03
1.504e+03
1.003e+03
5.013e+02
0.000e+00

Von Mises Stress, Forward (Z) loading- 9.0g



All Bolts	Lateral (x), 3.0g	Down (y), 4.5g	Forward (z), 9.0g
Joint Sliding	3.2	0.7	0.4
Tensile Yield/Ultimate	1.3	1.3	1.3
Ultimate Shear	>10	>10	>10
Comibed Shear / Tension	1.3	1.3	1.3
Bearing	>10	5.3	7.1
Tear out	>10	4.7	6.4

Risk Matrix

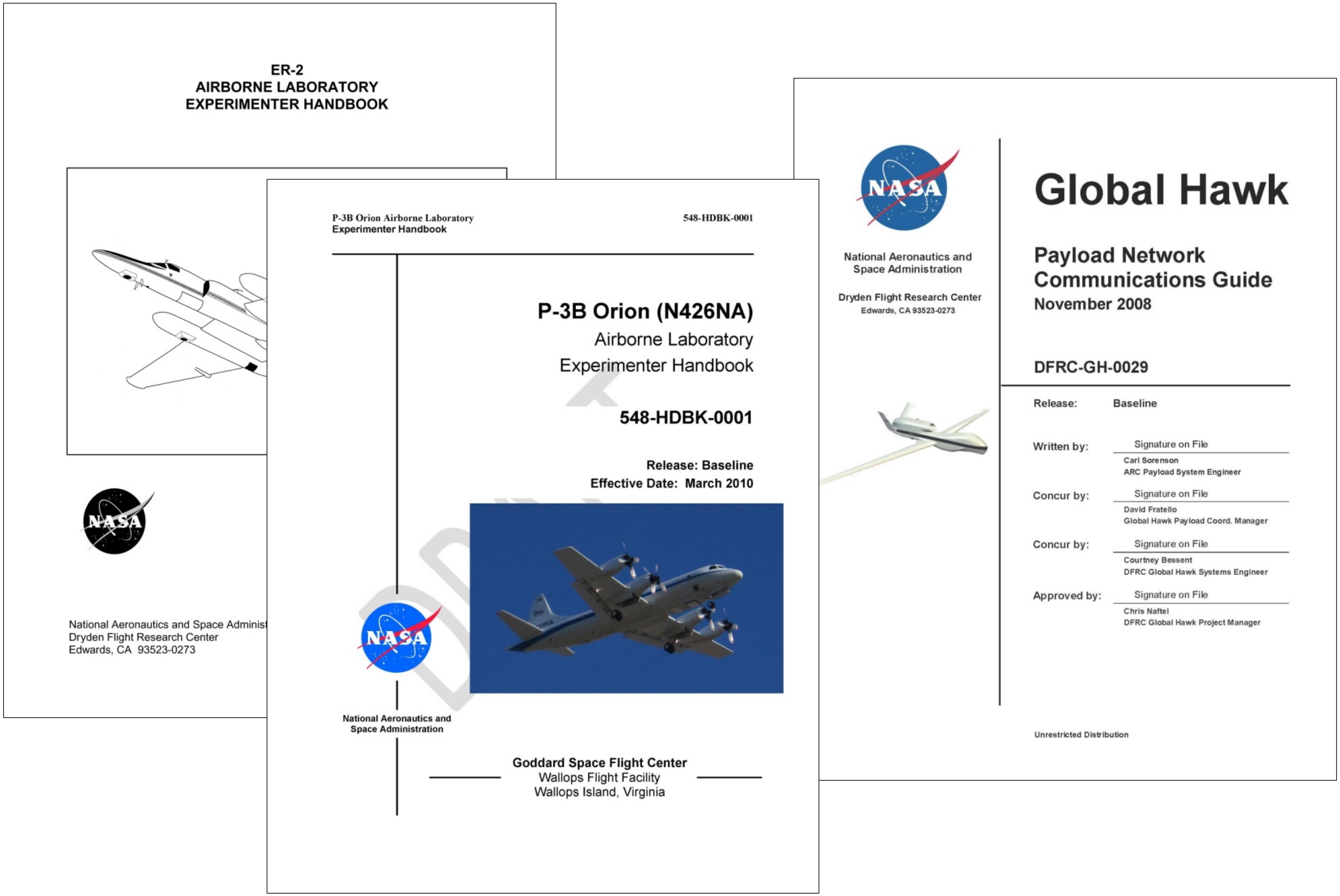
Consequences

Likelihood	Very Low	Low	Moderate	High	Very High
Very High					
High					
Moderate		2			
Low			4	1	3, 5
Very Low					

Risk	**1** – Instrument malfunction generates smoke in aircraft cabin
Mitigation	Pilots open two windows and extra air flow eliminates smoke hazard. Twin Otters are unpressurized.
Risk	**2** – Nadir port mounting hardware brackets present tripping hazard in cabin
Mitigation	Padding and orange tape covering bracket to increase visibility and reduce damage from impact. Pilots and science crew will be seat belted in for flight.
Risk	**3** – Fuel starvation of aircraft
Mitigation	Systems/procedures in place. HAMMR science crew provides additional eyes and ears.
Risk	**4** – Weather is worse than minimum conditions for flight.
Mitigation	No take-off without acceptable conditions for VFR operation during science data collection. Ground hold / delay / 24-hour schedule slip
Risk	**5** - Low altitude flight over water; limited glide range in event of critical aircraft system failure
Mitigation	All flights will be in daylight, fair weather and low wind conditions, minimizing situational awareness risks. Dual pilots, with a radar altimeter system to monitor altitude. Aircraft can climb at >100 ft/min on single engine at max gross weight and is capable of safely returning to base. Standard military equipment and practices for emergency ditching situations, cabin and crew rafts, and EPIRB (Emergency Position Indicating Radio Beacon).

General Documentation Online at the ASP Website

(User handbooks for the core platforms, and a Coms guide for network access)



ER-2
AIRBORNE LABORATORY
EXPERIMENTER HANDBOOK

National Aeronautics and Space Administ
Dryden Flight Research Center
Edwards, CA 93523-0273

P-3B Orion Airborne Laboratory
Experimenter Handbook
548-HDBK-0001

P-3B Orion (N426NA)
Airborne Laboratory
Experimenter Handbook

548-HDBK-0001

Release: Baseline
Effective Date: March 2010

National Aeronautics and
Space Administration

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia

National Aeronautics and
Space Administration

Dryden Flight Research Center
Edwards, CA 93523-0273

Global Hawk

Payload Network Communications Guide
November 2008

DFRC-GH-0029

Release:	Baseline
Written by:	Signature on File Carl Sorenson ARC Payload System Engineer
Concur by:	Signature on File David Fratello Global Hawk Payload Coord. Manager
Concur by:	Signature on File Courtney Bessent DFRC Global Hawk Systems Engineer
Approved by:	Signature on File Chris Naftel DFRC Global Hawk Project Manager

Unrestricted Distribution

http://airbornescience.nasa.gov

Includes:

- Flight Request system (“SOFRS”)
- Platform specifications and POCs
- The Experiment Interface Panel User Guide
- Other misc. documentation & much more

- Network Communications Guide:

http://www.eol.ucar.edu/raf/Software/iwgadts/DFRC-GH-0029-Baseline.pdf